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Barriers to Implement Integrated Prefabricated Facade Development in A Traditional Procurement Context in China: A Case Study

Li Shan[a,*]

[a]*City University of Hong Kong, Architecture and Civil Engineering Department, B6502, Tat Chee Avenue, Kownloon, Hong Kong*

Abstract

China promotes prefabrication technology in façade industry, which encourages the utilization of prefabricated façade system. Prefabricated façade system needs more integration, which can be achieved through reorganizing the façade development process. Theoretically, integrated principles would be helpful to reorganize the process in achieving integrations. However, in implementation, Chinese façade professionals face barriers, due to current delivery practice and traditional procurement context. The purpose of this paper is to present a case study on the attempt to reorganize façade development process to enjoy the benefits of integration in a traditional Design-Bid-Built (DBB) commercial building project, in China. The scope of the paper covers: i) the current façade development process, and the problems faced by façade subcontractor, ii) the constructive façade development process inspired by integrated delivery principles, and iii) the barriers to implement new delivery process. It was found that the benefits of the integration may not be completed realized on façade subcontractor side due to some task-related barriers, contract-related barriers, and people-related barriers. Suggestions for those who are working or will work in Chinese façade industry are provided.

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Keywords: integrated delivery; prefabricated façade development in China;

* Corresponding author. Tel.: +852-34422903; fax: +852-34422903.
E-mail address: sli222@cityu.edu.hk

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1. Introduction

This paper describes an attempt of reorganizing a prefabricated façade development in a traditional DBB commercial shopping mall project in China. The aim of the paper is to investigate the problems of current façade development process, the potentials of using integrated principles to reorganize the process, and the barriers to implement new process. The focal point for discussion is the issues that arise because of an integrated façade package being embedded in a traditional DBB project context.

The project environment (Section 2) led the client to choose DBB contract form in delivering a commercial shopping mall project. Considering the special requirements on façade, with the intention to provide opportunities for integrations in façade development, client packaged all façade related works into one contract and delivered to the main building contractor. However, façade design subcontractors realized that several problems exist in current façade development process in achieving integrations (Section 4). Guided by integrated delivery principles, a constructive process was presented (Section 5). However, to realize the benefits of integration, some barriers should be removed (Section 6).

The contribution of this paper is that an attempt to install an integrated façade development in the DBB project is studied and analyzed. Further, problems and barriers were also identified. The significance of this paper is that in future, clients who need to procure façade-design-oriented projects can adopt the constructive integrated practices proposed in this paper. In addition, façade professionals can use the constructive process to determine the right time, and appropriate activities to merge façade development with the whole project process, thereby realizing the benefits of integrations. Due to privacy issues, in this paper, some genuine facts are expressed by using pseudonyms. Data were collected by questionnaire survey and interviews with seven project participants, from both client and façade design subcontractor sides. To ensure that the interviewees were selected in a good mix of profiles, besides the client, on façade design side, one design manager, one principal architect, two architects, an architect assist, and a design coordinator were surveyed and interviewed.

Data were collected through three steps. Firstly, interviewees were asked to describe the project environment, existing façade development process, and to identify the existing problems of current process. In this step, interviewees from both client and façade sides participated. In step two, only the interviewees from façade sides involved. The integrated delivery principles were discussed between interviewees and author. The reorganized façade development process, and constructive activities were proposed. In the last step, the barriers to implement the constructive process were identified.

2. Project Environment

China promotes prefabrication technology in construction industry, and it is predicted that the prefabricated buildings will occupy more than 20% of the new buildings by 2020, and 50% by 2025 [1]. Paralleling with the urbanization in China, the market of façade industry kept increasing in the last 10 years. From 2006 to 2011, the gross output value of Chinese construction façade industry rose from 60 billion RMB to 180.3 billion RMB, at the Compound Annual Growth Rate (CAGR) of 24.6%. It hit RMB400 billion by 2015, and the CAGR during 2011-2015 was 21.7% [2]. And it is forecasted that the curtain wall market in China will grow at a CAGR of 18.98% from 2016 to 2020 [2].

In 2015, a private developer S decided to develop a commercial shopping mall CP in HZ, China. Though S had years of experiences in commercial real estate, CP is her first project to enter HZ's market. Client S expected to highlight her position in HZ's market through the unique façade designs, and thereby attracting business investors and commercial tenants. S was experienced in handling commercial shopping mall projects, while she had no experiences of using prefabrication technology. Noticing that HZ's prefabrication industry is well developed, S decided to take good use of the advantages of local construction industry, and thereby adding value to her project. S's objectives were to increase profit margin by providing unique façade design, maximize cost savings, and minimize risks. In addition, S also highlighted the maintenance issues involved in the whole life-cycle of the façade. S also wanted to learn and collect experiences of using prefabrication technology for her sustainable development.

To ensure that she would not loss the close control and supervision in this façade-design-oriented project, S adopted DBB strategy. In addition, considering the required integrations in prefabricated façade development, S collected the façade workings into one package and delivered it to the main contractor.

3. Façade Package

The mall is totally 14 stories, including 3 underground stories. The total height is 49.98 meter, and the total façade area is 45,800M^2. Briefly, the 2-storypodium and the 9-story main building use different façade systems.

In this project, contractor AR was selected as main contractor. AR is professional in delivering commercial shopping mall project, and AR was reputed in adopting innovative construction methods in local construction industry. With years of experiences in her home industry, AR had established strong networks with local façade designers and façade manufacturers. All these made AR the good candidate with the capabilities of creating integrations in the project.

AR divided the whole façade package into 3 working packages: façade design, fabrication, and installation. The reasons of making this arrangement were three. Firstly, AR could involve in the façade development by delivering installation works. Secondly, AR could keep her competitive in using particular innovative technology by selecting the installation methods compatible with construction methods. Thirdly, AR wanted to use the innovative installation methods to influence and control the façade design. Though the whole façade package was divided into several small working packages, AR was confident in creating the integrations in the façade development, by using her social networks with local façade designers and material suppliers. AR emphasized on the quality of the façade design subcontractor, especially the internal integrated capability and resources owned by façade designers.

The relationship between façade subcontractor and others are shown in Figure 1.

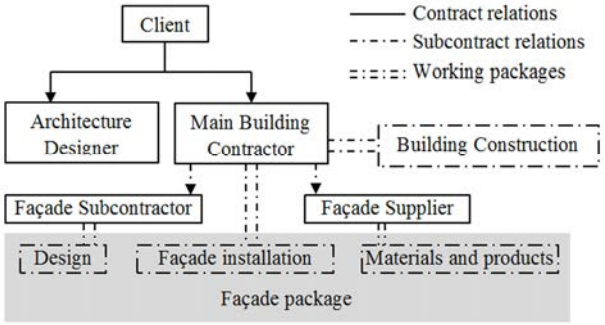

Fig. 1. Configurations of participants.

Façade design subcontractor X is a local designer, developing from an interior decoration company into a design-oriented construction company in the last 20 years. X has her own internal façade factory and façade installation teams, based on which she is competitive in using integrated façade development in HZ. Although X was equipped with the resources and capability to deliver the whole façade package in an integrated way, embedded in the current procurement context, she may not fully enjoy the benefits of her internal integration.

4. Current Façade Delivery Process and Problems

Based on the survey with interviewees, the façade development process in the CP project is shown in Figure 2.

Façade packages were delivered after the tender process. X's façade design was done based on the updated working drawings from architect. Before the detailed façade design, X supervised site to collect the fresh project information. The sequence of design deliverables was determined by the façade designer based on the site observation, and the drawings of the components which need to be constructed with the main building construction delivered firstly.

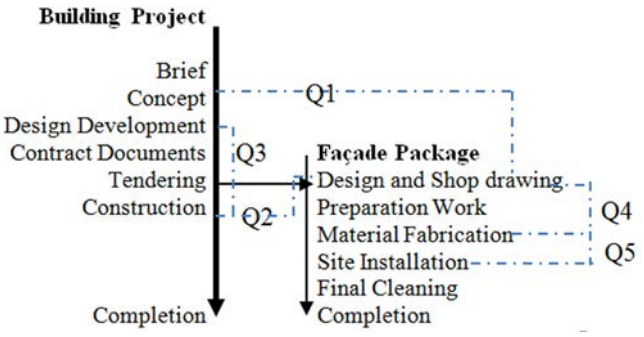

Fig. 2. The current façade delivery process.

After being approved by authorities, X's detailed design was used by AR to choose the façade manufacturers. The installation was carried out under the supervisions of construction manager and designer. In addition, client came to the site randomly to check the work.

The façade subcontractors completed their responsibilities after the project completion, by submitting as-built drawings.

Based on the survey, the problems (Qi in Figure2) in this façade development are of five aspects:

- Q1: Incompatibility between façade design and the architecture elevation design
- Q2: Incompatibility between façade system design and building system design
- Q3: Incompatibility between architecture design and construction design
- Q4: Incompatibility between façade design and manufacturing design
- Q5: Incompatibility between façade design and installation works

Briefly, façade designer did not involve in the architecture design stage, though she mentioned that this should be done to avoid Q1. The survey results showed that the task of "façade design" was differently understood by architect and façade designer. From architect's perspective, façade designer's work should be the deeper design based on architectural elevation designs. However, from façade design subcontractor's perspective, façade should be designed concurrently with elevations. In some special cases, façade design should be done in advance to lead the massing and elevation designs. Since CP's façade design happened after the tender, the conflicts between façade and building system could not be avoided (Q2). Interviewees also mentioned that buildability issues, poorly addressed in this DBB context, brought further problems to façade designer (Q3). To address Q3, on-site communications among construction manager and façade subcontractors should be provided. However, they were not successfully carried out due to the façade delivery methods adopted. Due to Q3, detailed façade design had to be changed from time to time, and these changes brought troubles to link façade design and manufactures, and thereby the poor components supply and installation (Q4 and Q5).

5. Constructive Façade Process

In the interview, integrated principles were proposed as a way to improve the façade development process. The integrated delivery principles were collected based on the [3,4,5,6], including well-defined contractual relationships, early definition of project goals, early team formation, integrated leadership, compensation linked to project outcome, experience implementing integrated delivery, appropriate technology/BIM, lean construction methods, clearly defined scope of work, specific project goals, creating a team spirit of win-win for every team member, pre-existing environment of trust, mutual support, transparent communication. Following these principles, the critical activities to reorganize façade design process is shown in Table 1.

Table 1. Constructive Façade Development Process.

Façade Development	Participants	Critical Activities
Preliminary Design Stage	Facilitator	Describe requirements, general end-user feedbacks, easy maintenance, light facade system, flexible assembles, etc.
	Client	Describe requirements, confirm the budget and construction period, establish common goals, and trust among participants.
	Architect	Realize the requirements and give suggestions on the available technology and materials.
	Façade Professional	Realize the requirements and give suggestions on the available technology and materials.
Concept Design Stage	User	Check whether the requirements have been met.
	Client	Check whether the requirements have been met. Set projects goals, including budget, functions, features, time, values etc. Set contractor selection criteria: experiences, value-adding design, optional design, network resources, interface management skills, etc. Set supplier selection criteria: professional knowledge on using materials, maintenance methods, and environmental-friendly issues, etc.
	Architect	Confirm the building design, work as client's consultant to choose the facade option which can be the best expression of the architecture, etc.
	Façade Professional	Provide construction qualification and previous project performance experiences, provide optional designs, and submit optional design report, etc.
	Supplier/Manufacturer	Provide qualified material, provide options to add value to the project, provide materials information for client and contractors, etc.
Tendering	All Stakeholders	Select design among options by using simulations, choose the partners, establish a risk sharing compensation system, clarify the rights and responsibilities for different parties, etc.
Detailed design Phase (Interface of different parties)	Façade Professional	Identify installation methods, establish building information models, clarify the rights and responsibilities of different parties involved in detailed design, establish a platform to coordinate information from different parties, etc.
	Interior Designer	Bound of work, handover of fireproof and water proof, etc.
	Structural Engineer	Make sure facade system hanging on major structure, etc.
	E&M Engineer	Make sure facade drainage system would not affect internal drainage system, make sure the equipment or machine would run smoothly with enough space and sufficient energy, etc.
	Supplier/Manufacturer	Elevation division sizes up to the standard and workmanship of materials.
Construction design	Façade Professional	Purchase materials.
	Supplier/Manufacturer	Supply materials.
	Project Manager	Monitor project process.
Construction	Supplier/Manufacturer	Supply materials.
	Project Manager	Monitor project process, and guide the installation with the support of BIM.
	Employees	Installation with the support of BIM.
Maintenance	Facilitator	Clean and fix on time.

Following these critical activities, interviewees proposed the constructive process which should be moved forwards to the front stage of the building delivery process (See Figure 3).

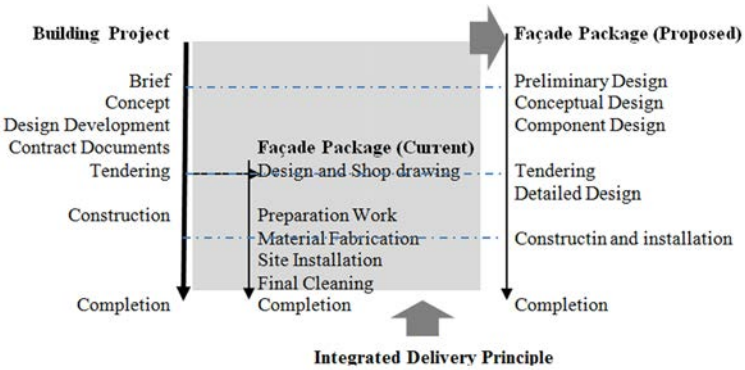

Fig. 3. Proposed façade delivery process.

Interviewees stated that façade development should be carried out at the very beginning of the building project. In particular, in the definition stage, requirements, especially those relevant to elevation design and façade design should be highlighted. The contract-related information should be collected from the conceptual design stage, when the interests of all stakeholders were discussed. The problems between designer and suppliers could be predicted once the component design was carried out. And concurrently, the constructability and manufacturability issues should be discussed. Since the constructability issues may not be well addressed in traditional DBB context, the component design could be used as another mechanism to integrate the design and construction sections. The detailed façade design can be carried out once the building construction started, with more focus on the maintenance and sustainability issues. As shown in Table1, facilitators, end users, suppliers and manufacturers should collaborate with other traditional participants from the early stage of the project.

6. Barriers in Implementing Integrated Delivery Principles

Though integration bring benefits to project, the realization of these benefits is not easy. Interviewees identified the barriers in the implementation process, which were classified into three categories, including:

- People-oriented barriers: new criteria of partner selection, much more complicated social network structures and interfaces than before, information sharing and decision making mechanisms, the new organizational structure and cultures, etc.
- Task-oriented barriers: changing delivering environment which requires more team flexibility and tacit knowledge sharing, technological issues resulting from using intelligent communication platforms, uncertainty showing issues due to the undefined and unclear risk and profit sharing mechanism in this new delivery environment, etc.
- Contract-oriented barriers: the ways to operationalize the integrated relationships in the contract documents, the insurance measures, etc.

Based on the survey results, façade designers further explained that:

- The contract-oriented barriers should be firstly broken down, since they were critical in creating the integrated project context. Without the integrated project context, the benefits of integration may not be realized, though integrated practices were adopted.
- Capabilities and resources to establish own internal integrations may help façade designers to remove task-oriented and people-oriented barriers. In addition, internal integration might be useful to motivate the creation of external integrations, and thereby addressing some problems resulting from the contract-oriented barriers.
- Though the clients would like to promote integration in the façade design-oriented project, due to the insufficient knowledge of integrated façade design, the implementation will not be successful. The role of the façade professionals should be emphasized in defining the building and its performance.
- Using façade design to differentiate the design product in a particular market was useful to enhance client's business performance, only when the benefits of integrations had been realized in façade development process.
- The facade professionals, though normally being contracted as subcontractors, should plays critical role in architecture design stage in façade-design oriented projects.

7. Conclusion

This study presents the potential of using integrated façade development in a traditional DBB project, providing practicality of applying integrated principles in prefabricated façade package in current Chinese DBB context. It shows that reorganizing the façade development process can help to improve the integrations in the façade package, by merging the façade development with whole project process by using appropriate activities.

Although, theoretically, integrated principles are useful in obtain integrations, the project procurement environment influences the implementations. In particular, façade professionals may face three categories of barriers, including people-oriented, task-oriented, and contract-oriented barriers. Strong internal integrations could help façade professionals to breakdown people-oriented and task-oriented barriers to a large extent. However, it would be difficult for façade professionals to realize the benefits of her strong internal integration, if the external integrations among the other participants on the value chain have not been well established.

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